

THE INNERVATION OF THE ACHSELBOGEN MUSCLE. By J. T.
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IN the year 1888 I described a case of bilateral achselbogen muscle in which I had traced the nerve supply on one side to the intercosto-brachial nerve, and on the other to the internal anterior thoracic nerve (1). At this time I had been unable to discover any previously recorded case of innervation of the muscle. Subsequently, it appeared that von Bardeleben had in 1881 (2) described a case of the innervation of the muscle from the internal anterior thoracic nerve; and that Cunningham had communicated to the British Association Meeting at Montreal, in 1884, two otherwise unpublished cases of innervation of the muscle from a similar source.

On the basis of its innervation, as known to me in 1888, together with what was then known of the morphology of the achselbogen muscle, I ventured to advocate that theory of the homology of the muscle first propounded by Turner, *i.e.* that it should be interpreted as a representative of the panniculus carnosus of other mammals.

During the considerable period which has elapsed, there has grown up quite an extensive literature dealing with the morphology of the achselbogen muscle. Not only have a large number of cases been recorded in which the anatomy and innervation of the muscle in all its tolerably varied forms have been accurately described, but the comparative myology of the entire axillary region has been exhaustively investigated. During this period, too, the foundations, at least, of a knowledge of the normal ontogeny of the muscle groups concerned have been well and truly laid.

The course of subsequent investigation has, in the main, tended to confirm the view espoused in 1888, but the apparent discrepancy between the mode of innervation by way of internal anterior thoracic and intercosto-brachial nerves respectively, has seemed unintelligible to some subsequent observers.

There can now be no doubt that, as a general rule, the nerve to the achselbogen is given off from the anterior thoracic (pectoral) nerves. I have now before me records of my own observations on the innervation of twenty-five individual achselbogen muscles. In thirteen instances the nerve of supply came from the anterior thoracic nerves alone; in eleven cases out of the thirteen the internal anterior thoracic nerve was alone con-

cerned. In one additional case the immediate source of innervation was the nerve of Wrisberg only, which for this purpose may be regarded as a branch of the internal anterior thoracic nerve. In eight cases the nerve supply was from sources towards which the anterior thoracic nerves contributed to a greater or lesser extent. It must not be assumed that in each of these eight cases the anterior thoracic nerves contributed the whole of the motor fibres. In one of these cases, at least, this was demonstrably impossible, owing to the minuteness of the filament connecting with the anterior thoracic nerves. In three instances I have found the achselbogen nerve to be derived from the intercosto-brachial nerve, although in one of these cases the nerve of supply to the muscle was joined by a filament from a ramus lateralis of the first intercostal nerve which was present in that particular case.

Tobler (3) has investigated the question of the innervation of the human achselbogen, along with that of its common mammalian prototype, the panniculus. It has long been known that the nerve of the panniculus formed an important constituent of the "lateral cutaneous nerve of the thorax," and that this constituent leaves the brachial plexus along with the anterior thoracic nerves. In other words, it is practically an offshoot of the pectoral nerve supply.

It can hardly be said that Tobler has contributed anything actually new in principle to our knowledge of the innervation of the panniculus. His special contribution consists in (a) a closer identification of the nerve of the panniculus with the pectoral nerve supply, which follows not merely from their usually common origin from the plexus, but also from the now accepted morphological community of the pectoral and panniculus sheets; and (b) the absolute denial of any motor innervation whatever of the panniculus by way of rami laterales of intercostal nerves, in spite of frequent numerous perforating rami of the latter, and of ansal communications between these and the nerve proper to the panniculus. Tobler further maintains that the human achselbogen is invariably supplied by a branch which comes from the pectoral (*i.e.* anterior thoracic) nerves, that branch being the true homologue of the nerve to the panniculus of mammals.

To the major part of Tobler's statement on these matters I have no difficulty in subscribing. I demur only to his denial of the possibility that the rami laterales of any of the more cranial intercostal nerves may constitute a path for motor fibres to the panniculus or its homologue, the achselbogen. Tobler has shown that in other primates the rami laterales of intercostal nerves form looped anastomoses with the nerve to the panniculus, but he holds that from this plexiform connexion the filaments of intercostal derivation merely pierce the panniculus to supply the overlying skin.

Both Tobler and Ruge (4) vigorously criticise Kohlbrügge for his statement that "die proximalen Theile des Hautmuskels, welche in der Achselhöhle liegen, werden bei Semnopithecus von dem Ramus lateralis des N. dorsalis II oder auch III versorgt, und ist das gewiss die naturgemässe Innervation des Achselbogens."

With the admission of the derivation of the panniculus from the common pectoral myoblastema, its innervation from spinal segments at all remote from those innervating the rest of the pectoral mass becomes highly improbable. But this improbability must not be taken as dependent upon any inherent incompetence on the part of the rami laterales to form pathways for motor nerve fibres. Thus, when Tobler remarks, "dass uns die Rami laterales als sensible Hautaste bekannt sind," he simply begs the question. I admit that the statement is for the most part true in fact, but I believe that I am able to show that it is not invariably true in the case of the rami laterales of the first two or three intercostal nerves. Tobler wholly ignores the whole question of variability in the paths which segmental nerve fibres may take to reach their destination; yet numerous instances of such variability are well known to every human anatomist, and there is no reason to believe that the limits of variation are narrower in the case of other mammals.

To both Ruge and Tobler (*cf.* especially (3), pp. 487-88) an admission of the possibility of achselbogen innervation by way of any ramus lateralis would appear to be tantamount to a repudiation of a constant neuro-muscular correlation. But surely this is by no means the case. It has never been understood that a genuine nerve-muscle correlation was inconsistent with some latitude in the paths chosen in different cases by homologous fibres.¹

¹ It is, at least, open to question whether the correlation of neuromere with myomere is, after all, of a perfectly rigid or invariable nature, or whether it is not rather homodynamic in character. We have learnt from recent experimental embryological work that the limb buds and other growing structures may be readily innervated from any growing nerve trunks which may be brought into appropriate structural relationship with them during early ontogeny; whilst the facts of pre- and post-fixation of the limb plexuses suggest a merely homodynamic equivalence between, *e.g.*, muscular nerves in a case of pre-fixed, and those in a case of post-fixed plexus, rather than a genuine segmental homology. It is true that, once a muscle mass receives its ontogenetic innervation, it will retain it throughout the course of the most extreme migration or transposition or topical distortion—as, for instance, in the case of the diaphragm; but prior to the establishment of the primitive neuro-muscular connexion it is not improbable that a considerable measure of heterotopic innervation is possible. The profound influence of phylogeny is probably felt mainly in the production of a general chronological recurrence of ancestral topographical relations, thus ordinarily securing a highly conservative type of innervation. Thus it may probably be affirmed that (a) the innervation of a muscle is a function of its early ontogenetic relationship to the developing peripheral nerves; (b) such relationships are tolerably, but not completely, constant; (c) early variations in the precise positions of the limb buds with reference to the embryonic axis are probably responsible for pre- or post-fixation of the limb plexuses, and other conditions associated therewith.

I therefore demur most strenuously to Ruge's conclusion when he says ((4), p. 504): "Wenn Wilson an dem nämlichen Kadaver den Achselbogen der rechten Seite aber von Nn. intercostales, den der linken Seite aber von Nn. thoracales anteriores versorgt sein lässt, so muss der Muskel in zweierlei Arten an einem und demselben Individuum in die Erscheinung treten können."

Ruge accepts ((4), pp. 485-87) an innervation of the achselbogen from the eighth cervical and first thoracic nerves by way of the brachial plexuses and its anterior thoracic branches. Let us assume that this is correct, at least in a large proportion of cases. Is there any essential tampering with the doctrine of nerve correlation if I assume (not gratuitously, but on grounds of observation, see *infra*) that the fibres innervating the achselbogen in some cases reach their destination *via* the first intercostal space and a ramus lateralis issuing from that space in series with other rami laterales? And if the validity of this interpretation be admitted, is it quite impossible to extend this method of interpretation so as to cover cases of innervation by way of ramus lateralis II or intercosto-brachial nerve? If it be the case that the achselbogen ordinarily belongs to the eighth cervical and first thoracic segment, then, from all that we know of pre- and post-fixation of the limb plexus, we ought to be able, not to admit merely, but to predict with confidence, that in some cases the same muscle will be found to be innervated as far forward as the seventh cervical, and in others at least as far caudally as the second thoracic segment. But Ruge, in connexion with this general problem, speaks as if segmental innervation is necessarily fixed and immutable.

It is difficult to understand the reluctance to admit the possibility of a nerve supply by way of the intercosto-brachial, alternatively with the brachial plexus, when the reciprocal size-relations commonly observable between this nerve and the nerve of Wrisberg are held in mind. Cunningham (5) long ago proved that these reciprocal relations were conditioned by the varying size of the communication which ordinarily passes between the second and first thoracic nerves. This, of course, simply means that there is a considerable number of nerve fibres which may reach the fossa axillaris and brachium in different cases, *either* by way of the brachial plexus *or* by way of the intercosto-brachial. The question must be pressed: "What are these fibres which in one case make up a tolerably stout nerve of Wrisberg, leaving the intercosto-brachial nerve small, and which in other cases are incorporated in a thick intercosto-brachial nerve, reducing the nerve of Wrisberg to a very slender filament?" In regard to this point I can hardly improve upon the statement interpretative of that apparent discrepancy in my original paper (*loc. cit.*, p. 298): "But when viewed in the light of Professor Cunningham's observations on the mutual relations of

the nerve of Wrisberg and the intercosto-humeral nerve, the character of the variation on the two sides proves rather confirmatory than otherwise of the views here advanced. In man, as in the typical mammalian brachial plexus of the porcupine, the lateral cutaneous nerve of the thorax (Wrisberg's) derives fibres from the most posterior of the roots of the plexus. Cunningham has made us familiar with the inverse ratio, in respect of size, which is occasionally noticeable between the nerve of Wrisberg and the intercosto-humeral nerve in man; in other words, he has pointed out the apparent indifference with which a number of fibres of the second intercostal nerve must pursue one or other of the two paths constituted respectively by the nerve trunks just named."

In support of this doctrine of alternative paths for nerve fibres belonging to the group under consideration, I was able in a subsequent paper to advance further evidence. I there showed ((6), p. 54) that nerve fibres supplying the skin over the plica axillaris anterior reached that destination by way of the anterior thoracic nerves after perforating the pectoralis mass. Here was a clear instance of a reciprocal relationship between the anterior thoracic nerves and the intercosto-brachial, for the skin area in question is ordinarily supplied through the latter path.

I am disposed to interpret the comparatively rare cases of achselbogen innervation by the intercosto-brachial nerve as occurring only in cases of marked post-fixation. I regret that I have not yet had the opportunity of testing this supposition by systematic examination of the whole spinal nerve series, more especially the entire brachial plexus, in any case of innervation from the source in question. However that may be, the fact of the occasional though rare occurrence of such innervation cannot be evaded by mere sceptical prejudice in favour of the admitted more common phenomenon.

Ruge as well as Tobler has clearly indicated his incredulity as regards my original observation of the innervation of the achselbogen through the second intercostal nerve. Ruge comments as follows on Cunningham's acceptance of my view that the achselbogen is to be identified as belonging to the second thoracic segment:—"Wilson ist der Gewährsman für Cunningham bei dem Zugeständnisse dieser Doppelinnervation. Warum, so fragen wir auch hier regten sich keine Zweifel an der Richtigkeit der einen oder der andern Angabe über die Nervenversorgung? Eine Nachprüfung wurde erforderlich, bevor eine durch vollkommene Untersuchungsreihen oft bestätigte Erscheinung in Zweifel gezogen werden dürfte. Es bleibt fraglich ob der Achselbogen jemals von intercostal Nerven versorgt wird" ((4), p. 485).

Apparently Herr Tobler's conception of the innervation problem is so

schematically simple that he also has no solution to fall back upon but that of faulty observation, when other observers, like Princeteau and the present writer, record exceptional instances of innervation which do not fit into his hard-and-fast scheme. Tobler ((3), p. 503) suggests that "Bei der erheblichen Schwierigkeit der Präparation des kleinen, langen Nervenfadens einerseits und der Häufigkeit der Anastomosen mit dem Intercosto-humeralis, sowie Fällen, wo dieser Nerv den Muskel bloss durchsetzte andererseits, kann man der Versuchung schwer widerstehen, Unvollkommenheiten der Präparation für diese Befunde verantwortlich zu machen."

Despite these innuendoes of the probability of errors of observation, I still maintain the accuracy of the description of cases already recorded, and I am now able to produce further evidence which should not merely remove doubt as to the possibility of an intercostal path of innervation to the achselbogen muscle, but which also illustrates tolerably clearly the nature of such an arrangement.

The following detailed account of the arrangement of the first and second thoracic nerves, as regards their relation to the innervation of an achselbogen muscle, serves, in my opinion, to illustrate very clearly that view of achselbogen innervation for which I am contending:—

In a microcephalic female subject, æt. 53, an achselbogen muscle was present on both sides. On the left side (fig. 1) there was present a ramus lateralis issuing from the first intercostal space in two divisions of unequal size; the larger division, which exceeded in size the intercosto-brachial nerve (ramus lateralis II), crossed the axilla under cover of the achselbogen and was distributed in the upper arm as a nerve of Wrisberg, which was otherwise absent. The smaller of the two divisions, shortly after issuing from the intercostal space, was connected by an exceedingly delicate looped filament of communication with the internal anterior thoracic nerve, and a little further on divided into two branches; both of these were joined by communicating branches from the intercosto-brachial, and the two nerves, thus reinforced, separately entered the fleshy belly of the achselbogen within which they were distributed.¹ The intercosto-brachial nerve was comparatively small, and, after giving off the communicating branches to the achselbogen nerves, was distributed to the integument over the plica axillaris posterior and adjacent part of the brachium.

A careful dissection was made of the rami ventrales (anterior primary divisions) of the first and second thoracic nerves (fig. 2). A very strong

¹ There was no possible doubt that these nerves did actually supply the muscle into whose substance they were traced. The dissection was carried out on the otherwise undisturbed body, which was in perfect condition, and was conducted explicitly and exclusively with the end in view of tracing out these nerve-relationships.

ramus communicans passed between these rami ventral to the neck of the second rib (*cf.* Cunningham). This thick communicating branch consisted of two fasciculi. The more medial of these fasciculi (fig. 2, *a*) appeared to consist of fibres passing from ramus ventralis I to ramus ventralis II.

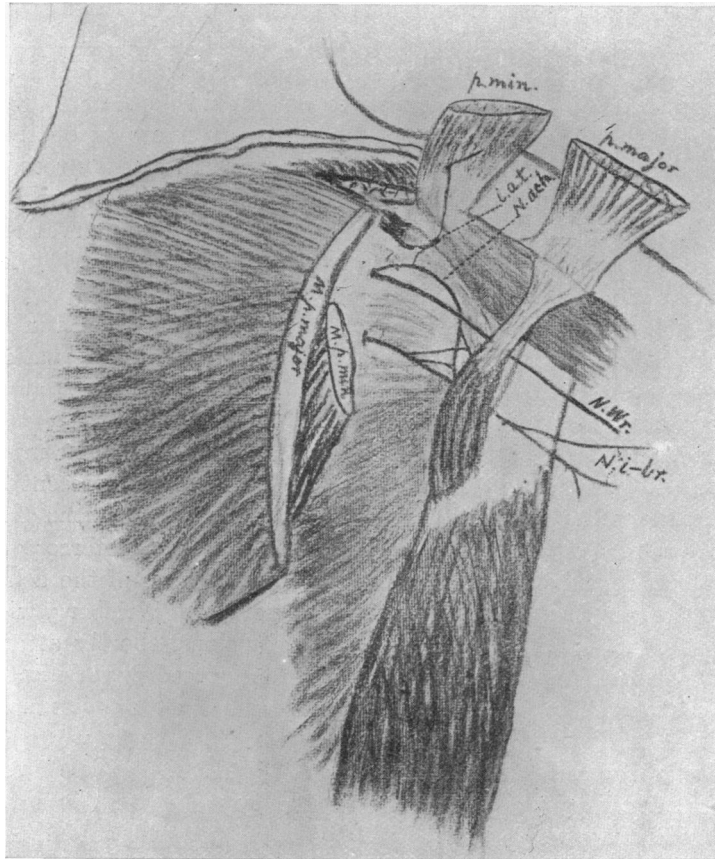


FIG. 1.

There can be little doubt that the fibres of this fasciculus joining the second intercostal nerve were continued into branches which were further out observed to be furnished to the lower part of the muscles of the first intercostal space from the trunk of the second intercostal nerve. The second, more lateral, fasciculus (fig. 2, *b*) of the ramus communicans consisted of fibre-bundles passing cranially from ramus ventralis II to

ramus ventralis I, and then dividing into secondary fasciculi which were traceable into definite branches of the first thoracic nerve. The ramus ventralis (anterior primary division) of the first thoracic nerve separated into brachial and intercostal portions. The former joined the brachial plexus; the latter consisted of three fasciculi which passed laterally in the first intercostal space, caudally to the first rib. Of these fasciculi, that lying most cranially was distributed to the muscles of the first intercostal space; the next was the strongest and formed the larger of the two divisions of the ramus lateralis which pierced the muscles of the first space

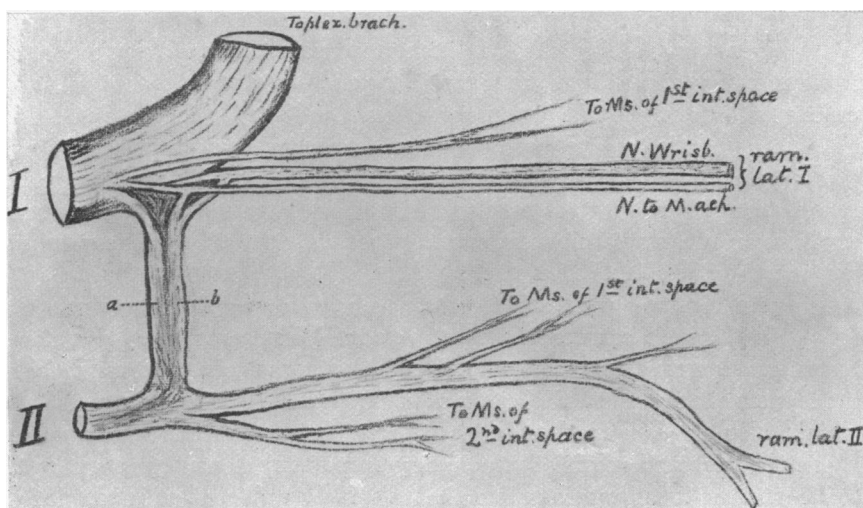


FIG. 2.

to enter the axilla accompanied by the third fasciculus, which, as already described, formed by far the greater bulk of the achselbogen nerve supply (fig. 2, *N to M. ach.*). Each of the two fasciculi, which together formed the ramus lateralis of the first intercostal nerve, were joined at their roots by those bundles of fibres which constituted the more lateral of the two fasciculi already noted as forming the ramus communicans between the first and second thoracic nerves.

I do not see how any unprejudiced observer can resist the conclusion that the greatly predominant nerve supply of the achselbogen muscle was in this case derived from the two upper thoracic nerves. The extremely delicate filament of communication with the internal anterior thoracic nerve, already noted, may possibly have conveyed some few fibres

from the eighth cervical nerve trunk, though I think it more probable, in view of the general post-fixed type of arrangement, that it either consisted of additional fibres coming from the first thoracic nerve, or that it consisted wholly or largely of fibres which joined the internal anterior thoracic nerve from ramus lateralis I, to supply more caudal fasciculi of the pectoral mass. An actual investigation of this subsidiary question was not carried out. In any case, it will be evident that the contribution towards the innervation of the achselbogen from the second thoracic nerve was in all probability twofold. In the first place, it is certain that a considerable fasciculus of fibres from the second thoracic nerve entered the main nerve to the achselbogen by way of the ramus communicans leading to the first thoracic nerve; and in the second place it is, in my opinion, extremely probable that additional motor fibres from the second thoracic nerve were conveyed to the achselbogen by way of the communicating filaments from the intercosto-brachial nerve which joined both the achselbogen twigs of supply (*cf.* fig. 1). At the very least, this case places beyond all reasonable doubt the possibility of the innervation of the achselbogen along the path of a ramus lateralis of an intercostal nerve, instead of only along the path ordinarily taken, *via* the anterior thoracic nerves.

Owing to circumstances of the dissection, the nerve arrangements in the right axilla were not completely ascertained, but no ramus lateralis of the first intercostal was present at all, and there was some reason for belief that the nerve supply on that side was not derived from the intercosto-brachial; also it was found that on this side the ramus communicans between the first and second thoracic nerves was much smaller than on the left side, so that it is quite possible that a widely different condition might here have been met with.

A descriptive account by the writer of other cases of occurrence of the achselbogen muscle will shortly appear in the *Transactions* of the Australasian Medical Congress of 1911, in connexion with a review and discussion of some of the literature dealing with the muscle in question.

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¹ For a bibliography of achselbogen, reference may be made to Ruge's and Tobler's papers above cited, and for the more recent papers, to the papers of Heiderich (7), Bluntsehli (8), and Gruschka (9).

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EXPLANATION OF FIGURES.

Fig. 1.—Sketch of dissection of axillary region to show arrangement of rami laterales of upper intercostal nerves.

i.a.t., internal anterior thoracic nerve (*n. thoracalis anterior med.*); *N.ach.*, nerve to achselbogen; *N.Wr.*, nerve of Wrisberg (*n. cutaneus brachii medialis*); *N.i.br.*, intercosto-brachial nerve.

Fig. 2.—Semidiagrammatic sketch of the arrangement of branches of the rami ventrales of the first and second thoracic nerves. (After careful dissection, the entire arrangement figured was excised and subjected to minuter preparation and scrutiny, and then drawn.)

a, medial fasciculus, *b*, lateral fasciculus, of the ramus communicans between ventral rami of first and second thoracic nerves.